your development with the greatest interest, expecting to learn much from the way you meet the educational problems of a developing medical science.

To the authorities of Stanford University I can only say, cherish well this new offspring of your university, nourish it carefully, expend on it richly of your resources, that an institution may grow here, a pride to the university, to the state and to the country. In its proper development you will richly reap from your investment, even though the investment be very great. May the medical department of Leland Stanford Junior University have a long and useful career, may its faculty and students contribute richly to the widening of the horizon of medicine, and may its future graduates carry comfort and healing to thousands of suffering humanity.

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SUGGESTIONS FOR THE CONSTRUCTION OF CHEMICAL LABORATORIES[1]

General Construction.—For a chemical laboratory there is probably nothing better than the so-called slow burning or mill construction. While lath and plaster may be more handsome from an artistic point of view, yet it suffers from the serious disadvantage that the ceiling becomes disintegrated from the acid fumes, with the inevitable result that it drops into the quantitative determinations, to their ruin, or hangs in festoons or fragments that are anything but artistic.

Walls.—The walls should, if possible, be faced with white glazed brick; if this be prohibitive on account of cost, at least where they are exposed to view. In place of this, possibly pressed yellow brick, white "silica" brick, or ordinary red brick painted white may be employed. The paint employed should contain no "white lead," but may be sublimed lead ($PbSO_4$), barytes or zinc white, or preferably a mixture of these in about equal proportions or lithopone. Some of the so-called cold water paints have been used with fairly good success. They may turn black in damp weather, but usually return to their white color when dry.

Floors.—If care be taken to keep the joints tight between the walls and floors there is probably nothing better for a laboratory floor than asphalt. The writer knows of some laid twenty-five years ago that have required no outlay for repairs and are apparently good for another quarter century. Laboratory desks and heavy apparatus should be supported on a broad framework to prevent them from sinking too deeply into it. The asphalt, as wood floors, should be laid upon a heavy grooved and tongued wooden floor with paper between. These floors can be supported upon double wooden beams or upon iron beams kept well painted with a metal varnish coating. Rift hard pine, birch or maple, when carefully selected and laid, makes a good floor, particularly if kept well oiled. This has the disadvantage of making it slippery. It is of course not as tight as an asphalt floor.

Ceilings.—Too much attention can not be paid to their construction, as the writer knows of three large new laboratory buildings in which a more or less constant precipitation of sawdust, paint and plaster is taking place upon the floor below, because of an oversight in this particular. This, in one case, is due to the application of a cold-water paint, which is scaling off from the ceiling when the floor above is walked upon. In the other two cases sufficient care was not taken to sweep clean the first layer of floor boards before laying the second. All

[1] This paper was practically in its present form in November, 1907, nearly a year before the articles lately published in Science.

this can be obviated by putting in a ceiling of matched boards *after all floors have been laid.* It should be finished with shellac or coach varnish. Something of a pitchy or resinous nature should be used (and yet contain no common rosin, as that is far from durable), rather than a paint which can peel or flake off. This should be borne in mind in all overhead construction. As has been said, plaster of any kind is inadmissible in a ceiling on account of its disintegration by acid fumes. Cement is no better, as in one laboratory of which the writer knows, a cement ceiling began to flake off within about six weeks after occupation.

Fire Walls and Protection.—The building should be subdivided into areas of suitable size by fire walls extending from top to bottom; all apertures in these walls should be guarded by automatic fire doors. The library, if there be a departmental one, should be housed in a fireproof room and also be protected from being flooded by leaks on the floor above. The more dangerous laboratories—the organic, the oil testing and those below or adjacent to the library should be rendered safer by the installation of sprinklers. Somewhere in the building there should be a fireproof room for the distillation of inflammable substances. In addition to fireproof stairways a sufficient quantity of outside iron fire escapes should be provided and the exits thereto carefully indicated and kept unfastened. Inch rubber fire hose with nozzle should be provided in each laboratory. Rubber is better than linen or any other collapsible type of hose, in that it does not kink and thus can be taken through doorways when there are self-closing doors without checking the stream of water. A number of small hose are better than large hose in the hallway, in that they are more accessible, and if used, do not deliver such a torrent of water as to occasion a greater loss from water than from the fire itself. Pails of sand with scoops are very efficient and should be found in every laboratory. No money, however, should be wasted on the purchase of "dry powder fire extinguishers," of which Dr. Freeman says "we recommend that they be thrown into the rubbish heap."[2] If these are wanted they can be easily made by filling tin tubes with two or three pounds of "anchor dust" or waste bicarbonate of soda. In the organic and oil testing laboratories or any other where the fire risk is unusual, in addition to these safeguards above mentioned and automatic sprinklers, some type of portable chemical fire extinguisher should be included. This, as is well known, employs carbonic acid generated by the action of sulphuric acid upon baking soda to throw a stream of carbonated water about, which is especially effective in tar and chemical fires.

A large douche bath with quick opening valve has been found very convenient in extinguishing fire on a student's clothing. This is merely a rose, or better a flat hollow disk a foot in diameter with concentric slits in it, through which the water issues in a shower; it is set seven feet from the floor.

Heating and Ventilation.—The so-called "plenum system" for the general heating and ventilating of a laboratory building may be said to work fairly well, but it must be supplemented by steam radiators and by independent fans, one or more for each laboratory, drawing upon the hoods. These can be placed in the laboratory or, better, on the roof. The hoods in addition to having the usual outlets at the top should be provided with an outlet at the bottom, as most of the gases and vapors of which the

[2] "On the Safeguarding of Life in Theaters," p. 87.

chemist wishes to be rid are heavier than air. Besides the fan draft in the hood the flue should be so arranged that a good sized Bunsen burner can be kept burning in it for use when the fans are not running.

Hoods.—These can in general be disposed of about the laboratory walls and be constructed of wood, pine, white wood, cypress or "asbestos wood" or "asbestolith" with wooden or asbestolith sashes. Where the material is exposed to steam, hot air, or unusually corrosive agents, they perhaps can be made of glass, wired glass, admitting of large panes set in lead-covered sashes.

Iron settings for the glass, unless kept well painted, are not to be recommended. Possibly these sashes may be omitted, and the hoods built after the manner of show cases of plate-glass show windows, by drilling and holding the glass plates in position by angle irons kept well painted with a pitchy "paint." The backs and tops of the hoods can be lined with the same material, where wood is inadmissible, and it is desired to secure freedom from scaling from the brick walls. The use of hoods extending over each desk, as in Edinburgh, is of doubtful expediency and renders the laboratory dark and fills the ceiling up with their exit pipes. The use of small low hoods at each desk would seem to render the piping system complicated and expensive. Except in very special cases the necessity of an individual hood close at hand is not very great. The bottoms can be made of concrete or wire lath, tile or soapstone, and the hoods should not be more than 18 inches deep. The ducts from the hoods can be made square or rectangular, of the wood or the asbestos compositions mentioned. If of wood they can be grooved and tongued, glued and nailed together and varnished. If made of iron they should be painted with an asphalt or pitchy paint, as "chrysolite" (Solvay Process Co.). Aluminum paint is not found to protect iron as well as has been claimed for it.

Laboratory Desks and Lockers.—So far as the writer's experience goes, the responsibility for their selection lies usually with the architect, and it is common experience that architecture and chemistry do not "mix"; that is, good architectural students are oftentimes deficient in chemistry.

Quartered-oak desks and alberene stone tops seem almost as much out of place amid the fumes and acids of a chemical laboratory as dress suits for the students. Even a casual visitor can not help having a pang of regret to see a fine quartered oak panel ruined by the attack of sulphuric acid or caustic soda. Speaking from wide observation and the experience of others, the writer is convinced there is no better (and in the long run cheaper) material for the tops of ordinary laboratory desks than wood. Tiling is always uneven, lead is untidy and expands but does not contract when heated, glass cracks, and all are cold to the touch. For the tops of laboratory desks or tables the following woods have been found to give good satisfaction: Northern pine, whitewood, cedar and California redwood. These may be finished with equal parts of linseed oil and turpentine, or, better, filled with aniline black made in the pores of the wood, according to the following procedure: Apply to the wood solution one, and after it has dried in, solution two: Solution I., 100 grams aniline hydrochloride, 40 grams salammoniac, dissolved in 650 c.c. of water. Solution II., 100 grams copper sulphate, 50 grams potassium chlorate, dissolved in 650 c.c. of water. Oak, ash, or cypress can not be recommended, the former two because they shrink too much and the last because it is very splintery. If the tops are made of two-inch stuff they can be planed down

from time to time and even turned over, when one surface is too far gone for planing. Such tops have been known to last with constant usage in an organic and analytical laboratory for nearly thirty years. These plank tops should be made of lumber as wide as possible and be carefully jointed and well glued together. When properly done it is rare that the glued joint starts. From some laboratories which the writer has seen it would not seem advisable to build the tops of narrow seven eighths inch floor boards even when fastened to a second seven eighths inch top; the joints open and the boards warp and curl making a very undesirable, uneven surface.

Desk Hardware.—For locking the desks, iron hasps and screw eyes and heavy padlocks have given excellent satisfaction even with freshmen, for twenty-five years' constant use. These locks[3] are bronze throughout, with brass or bronze springs and six secure levers, master-keyed, with changes permitting at least four hundred in a series: they are circular, except for the shackle, and about two and one fourth inches in diameter and cost about a dollar each. They should be oiled annually with a light non-gumming petroleum spindle oil. Padlocks have the advantage over mortise locks, keyed or keyless, in that if they fail to open the screw eye can be cut with a blacksmith's bolt cutter, the padlock removed and the cut screw eye replaced by another. The damage to the desk is nothing compared with that incident to forcing a drawer or hammering the lock loose or off by a punch on the round key-hole standard. They have the additional advantage that they, being laid on their side, in the drawer when not in use, are not exposed to the corrosive action of chemicals spilt upon them. These run down the mortise lock around the bolt and levers and stick them fast. Their sole disadvantage, as against combination locks, lies in the loss of the key. The losing of keys can be largely prevented by requiring the use of key chains attached to the bunch of keys and also by informing the student that they are charged one dollar each if lost. They have the advantage that they are much more easily opened, while if the combination be forgotten the instructor has to search it up in the records. Unless the combination on each lock be changed annually, an elder student, a sophomore, for example, would have access to the desk which he used as a freshman, which is now occupied by another student, a serious disadvantage. The changing of several hundred combinations annually is no trifling task. Hard-wood knobs are to be preferred to metal knobs or handles. The Fogg adjustable ball catch with the ball on the *standing* part of the desk has given excellent service. Iron hinges are apparently as good as brass and are cheaper.

Piping and Drainage.—All pipes and drains should be arranged so that every foot can be easily rendered accessible for inspection and repairs. This can be brought about by the "top system" of pipes and drains on the desks and these connected with the main system under platforms running along one end of the desks. Or the piping can be arranged upon the back of one line of desks and the other line, which is movable, backed up to it. Iron piping should be used as far as possible, the outside being painted with a pitch or asphalt paint. Lead lined pipe instead of lead would seem to be satisfactory for suction. For peaty service waters, black pipe fills up rapidly with zooglea, crenothrix and iron rust. This can be avoided to a large extent by the use of galvanized iron or lead-lined pipe. For drainage the lead-lined or even plain

[3] Made by the Miller Lock Co., Philadelphia, Pa.

wooden troughs kept well painted with thin coats of asphalt have given good satisfaction. They are much to be preferred to lead pipes, which continually give trouble from clogging. In concrete construction the writer has these troughs replaced by trough-like depressions made in the floors and lined with asphalt. Care should be had to make these of sufficient capacity and fall; they are covered with slate or cast-iron slabs. The vertical drains should be constructed of hard baked Akron tile or better yet, chemical pottery, and the joints made with cement or possibly with the same material as the asphalt floors. These vertical drains can either be in the elevator well or in a square space in the wall, it being closed with doors so that they too, are readily accessible. Individual traps and vents are not needed in the various laboratories, but the whole system should be effectively protected by traps in the basement. For sinks the ordinary round stoneware wash bowl may be used. This is made with an overflow, and instead of the usual brass fitting at the bottom a porcelain tube two or three inches long projects from it, carrying eyelets at the top on either side of the bowl. The tube fits down into a piece of lead pipe two feet long which empties into the trough on the back of one line of desks. This lead pipe is supported at the top by the eyelets just mentioned. These pipes can then be easily replaced by the janitor, the services of the plumber not being needed. Each laboratory should be provided with valves so that the steam, water and gas can be shut off from it without disturbing another room. The gas valve should be placed near the exit so that it can be closed nightly and diminish the danger from fire.

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Massachusetts Institute of Technology,
March, 1909

THE PRINCIPLES OF THE CALCULUS AS APPLIED IN THE TECHNICAL COURSES OFFERED AT THE UNIVERSITY OF ILLINOIS

Considerable discussion has been aroused in mathematical and engineering circles by the publication in Science of the papers presented at the symposium on mathematics for engineering students held in Chicago at the time of the joint meeting of the American Mathematical Society and the American Association for the Advancement of Science. The committee appointed soon after this meeting is now formulating a course in mathematics intended primarily for engineering students, and their outline will undoubtedly be accepted as a syllabus of the mathematics required by students in technical courses throughout the country. In this connection it may be suggested that some notions as to the contents of such a course might be obtained from an investigation of the various technical courses offered at some university maintaining a school of technology of recognized standing. It would be of interest to know what principles, say of the calculus, are actually used, and how often, in a single complete course or group of technical courses. Data on the relative frequency with which these principles are used might suggest the amount of emphasis to be accorded each in a course of mathematics for engineers. On the other hand, such data should also suggest to the teacher of mathematics those principles which, though not emphasized in the application, should constitute an important part of any well-rounded course in the calculus. The gaps to be thus filled become apparent on investigating what principles of the calculus are emphasized throughout the technical courses actually offered.

In this investigation I have considered the technical courses as offered in the college of engineering of the University of